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COMPLETE SPECIFICATION

A method of Bonding Polytetrafluoroethylene

We, E. I. DU PONT DE NEMOURS AND COMPANY, a corporation organized and existing under the laws of the State of Delaware, United States of America, of Wilmington, State of Delaware, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a method of bonding polytetrafluoroethylene.

One of the characteristic properties of polytetrafluoroethylene is its inability under ordinary circumstances to adhere to other materials. This unique property has frequently given rise to various useful applications of this resin. For example, polytetrafluoroethylene coatings have been employed on metal rolls which come in contact with molten polyethylene and these coatings serve the purpose of preventing adhesion of the polyethylene to the metal rolls. Polytetrafluoroethylene has also been employed in a similar manner in various mechanisms in which one member having a polytetrafluoroethylene surface is slidably disposed with respect to another member. While in these applications and in numerous others the non-adherent quality of the polytetrafluoroethylene has given rise to a valuable and useful result, this particular quality is quite undesirable in certain other practical applications. For example, the problem of forming an adhesive bond between a polytetrafluoroethylene surface and the surface of another material such as metal, glass, another plastic, or another polytetrafluoroethylene surface, or the like has been extremely perplexing. Certain methods have been devised for bonding a metal film to polytetrafluoroethylene in order to produce an interlayer which can be bonded to other materials. Various other relatively expensive methods have been employed in order to achieve the

desired result. None of these methods has been entirely satisfactory from the standpoint of efficiency and low cost.

An object of this invention is to provide an improved method of bonding polytetrafluoroethylene to itself or to other materials.

It has been discovered in accordance with the present invention that a polytetrafluoroethylene surface is significantly altered when contacted with a solution of sodium in liquid ammonia. It has also been discovered that the resulting surface is a highly effective means whereby polytetrafluoroethylene can be adhesively bonded to other surfaces.

The surface which is produced by the reaction of polytetrafluoroethylene with a solution of sodium in liquid ammonia is a black adhering residue which evidently is formed by a surface dehalogenation of the polymer. The black surface thus produced is difficult, if not impossible, to remove from the polytetrafluoroethylene by abrasion or other physical methods. The surface thus produced can be adhesively bonded to any other suitable surface such as metal, plastic, glass, wood, etc.

The invention is further illustrated by means of the following Examples:

EXAMPLE I.

A clean dry sheet of polytetrafluoroethylene was dipped into a 1% solution of metallic sodium in anhydrous liquid ammonia. A dark brown to black coating was produced on the polytetrafluoroethylene surface. The surface thus formed was bonded to a metallic aluminum sheet using an acidified phenol-formaldehyde adhesive under slight pressure at a temperature of 140° F. Good adhesion was thus obtained. The experiment was repeated using two sheets of polytetrafluoroethylene which had been surface-modified as above described instead of a polytetrafluoroethylene-aluminum composite. Similarly good adherence was obtained.

EXAMPLE II.

5 A sheet of polytetrafluoroethylene treated with a solution of sodium in liquid ammonia was bonded to aluminum by the method described in Example I except that commercial epoxy resin was employed as the adhesive.

Similarly polytetrafluoroethylene was bonded to sheet steel. The resulting bonds were tested for tensile shear strength and tensile strength with results as reported in the following Table: 10

TABLE I

STRENGTHS OF BONDS FOR POLYTETRAFLUOROETHYLENE TREATED WITH A SOLUTION OF SODIUM IN LIQUID AMMONIA

Type Bond	Adhesive	Tensile Shear (P.S.I.)	Peel Strength (A.S.T.M. Test D903-49)	Tensile P.S.I.
Polytetrafluoroethylene-Polytetrafluoroethylene	Epoxy resin	114	—	—
Polytetrafluoroethylene-Aluminum	Epoxy resin	104	41	—
Polytetrafluoroethylene-Steel	Epoxy resin	—	—	676
Polytetrafluoroethylene-Steel	Epoxy resin	—	—	430
Polytetrafluoroethylene-Aluminum	Epoxy resin	129	—	—

EXAMPLE III.

15 A polytetrafluoroethylene sheet was treated with sodium in liquid ammonia as above described and the resulting carbonized surface was cemented to a wood surface (oak) using commercial epoxy resin as an adhesive. A good adhesive bond was thus obtained.

20 The adhesive bonds produced in accord with the process of this invention are generally resistant to attack by chemicals which are resisted by the adhesive itself and the material to which the polytetrafluoroethylene is bonded. 25 For example, a polytetrafluoroethylene-polytetrafluoroethylene composite bonded according to the method of this invention by the use of a phenol-formaldehyde adhesive withstood boiling for several days in aqueous hydrochloric acid of 20% concentration. In similar test bonds prepared by the use of epoxy resins did not fail after 21 days in contact with refluxing 20% hydrochloric acid.

35 As indicated in the foregoing examples, the surfaces of the polytetrafluoroethylene prior to bonding should first be clean and dry; removal of any grease, etc. by means of an organic solvent is generally a desirable precaution.

40 The invention is highly useful in the manufacture of various articles which may be

composed of polytetrafluoroethylene bonded to itself or to other materials. Electrical insulation, spiral tubing, and various articles which are reinforced with fibrous polytetrafluoroethylene are examples of articles which can be made in accordance with the present invention. 45

What we claim is:—

1. A method of bonding polytetrafluoroethylene to itself or to other materials, which comprises treating the polytetrafluoroethylene surface to be bonded with a solution of sodium in liquid ammonia in order to modify the surface, and bonding the modified surface to another such surface or to another material with adhesive. 50 55

2. A method according to Claim 1 in which the polytetrafluoroethylene surface is modified by dipping it into a 1% solution of metallic sodium in anhydrous liquid ammonia. 60

3. A method according to Claim 1 or Claim 2 in which the adhesive is a phenol-formaldehyde adhesive or a commercial epoxy resin.

4. A method according to any of the preceding Claims in which polytetrafluoroethylene is bonded to metal, such as aluminium or steel, or to a plastic, or to glass or wood. 65

5. A method of bonding polytetrafluoroethylene to itself or to other materials substantially as hereinbefore described.

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